tinction between soma and sexual tissues comparable with that which in plants finds its expression in alternation of generations.

On the other hand, the proposal to replace the expression "double fertilisation" by that of "triple fusion" strikes us as a good one. It is by no means certain that the process indicated is really of the nature of fertilisation at all, and until more evidence enables us to form a reasoned opinion as to the meaning of these remarkable phenomena that precede the formation of endosperm in a large number of cases, it is better to avoid taking up, even nominally, what may prove to be a totally untenable position. Indeed, we already know that endosperm may arise, in some instances, independently not only of the addition of the extra male nucleus but also even of the fusion of the two polar nuclei themselves.

It is not possible to discuss the many points raised in this interesting work in any detail. Every serious student of botany will certainly peruse it for himself and can form his own judgment on controversial matters. He will be aided in this by the copious references to literature which form not the least valuable feature of this fine book.

Here and there we note an occasional slip, *e.g.* the suggestion that the investigations which have led to a general disbelief in the occurrence of centrosomes in angiosperms originated in Germany. But as a general rule the statements are remarkably free from inaccuracy. It is not possible to conclude this notice without commenting on the excellent manner in which the book is got up. The text, and especially the illustrations, both in character and execution, are all that could be desired.

J. B. F.

APPLICATIONS OF PHYSICAL CHEMISTRY.

Physical Chemistry in the Service of the Sciences. By J. H. van 't Hoff. Edited by Prof. Alexander Smith. Pp. xviii + 126. (The University of Chicago Press, 1903.) Price 1.50 dollars.

THIS handsome volume is based on a course of nine lectures delivered in 1902 at Chicago, where Prof. van 't Hoff was the guest of the university; it deals with the extension of Avogadro's law to solutions, and the thermodynamical principle of the conservation of energy; the thermochemical and electrical methods of determining what chemical changes are able to do work, and the theory of ionisation; the application of the phase-rule in relation to the extraction of pure salts from the Stassfurt deposits, and to the metallurgy of iron and steel; osmotic pressure in its physiological applications, and the catalytic action of enzymes; and the nature of the salts deposited by the evaporation of sea-water, and the reasons for their formation. The lecturer has thus, by carefully chosen examples, illustrated the bearing of modern physical chemistry on manufacture, on physiology, and on geology.

Prof. van 't Hoff tells a curious tale of the celebrated Kekulé, professor at Bonn, who thirty years ago took the pessimistic view that chemistry, as a science, had come to a stand, and that a Newton was necessary before further advance could be made. It was an unfortunate utterance, for no science has made greater strides within the last quarter of a century, and Prof. van 't Hoff has done much to contribute to its advance. The fortunate conjunction of three men, van 't Hoff with his magnificent powers of generalisation, Arrhenius with his keen insight, and Ostwald with his encyclopædic knowledge and rare gift of exposition, has largely aided the rapid progress of physical chemistry. But the first step was taken by van 't Hoff and Le Bel, in their simultaneously conceived theory of the representation of the molecule in three dimensional space.

In discussing the aid which physical chemistry has given to pure chemistry, the author states:—

> "The most recent development of physical chemistry has been characterised rather by the establishment of comprehensive principles which fertilise the whole foundation of the science, and which promise to furnish nourishment for a large part of the chemistry of the future."

A short explanation of the nature and laws of osmotic pressure is then followed by a brief statement of the nature of a reversible cycle and its application to the case of carnallite. The "principle of maximum work" is next considered, and the fallacy contained in it, and the suggestion is thrown out that all thermochemical work should be repeated, "with the object of determining the ability of each reaction to do work." This suggestion is again illustrated by help of carnallite as an instance. At $-21°$, the temperature of equilibrium between carnallite and its components,

$$MgCl_2KCl.6H_2O + 6H_2O \rightleftarrows MgCl_2.12H_2O + KCl,$$

the possibility of doing work is zero. But above this temperature, the reaction can overcome a resistance such as a pressure; hence $dE = -WdT/T$, and a cyclic change is possible. For finite values $E = -W\Delta t/T$; hence, while at the transition temperature where $\Delta t = 0$, $E = 0$, both above and below it the sign of E changes. Of course, at absolute zero, $E = W$, where $\Delta t = -T$, and the heat developed will be a measure of the capacity to do work, and the fact that Berthelot's principle of maximum work holds in many cases is merely due to the temperature of experiment being relatively low—only 273° above absolute zero. At 1000°, on the contrary, acetylene is formed with absorption of heat, and water decomposes in spite of the fact that its formation is accompanied by evolution of heat. This abridgment of van 't Hoff's argument will give an idea of the simple and clear method of statement. In a similar manner the connection of the capacity to do work with electromotive force is explained, and illustrated by the example of a thallium–thallium chloride–potassium thiocyanate cell. Arrhenius's conception of ions is thus introduced and shortly described.

In dealing with the connection between physical and industrial chemistry, van 't Hoff emphasises the circumstance that in Germany the most hearty co-operation exists between manufacture and science, alluding to the fact that it is not there expected that the physical chemists shall give "tips" to the in-

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dustrial chemists, but that the education of the latter as physical chemists will open up new points of view, and gradually lessen the purely empirical methods by which the industrial chemist often tries to progress. The salt industry is next discussed; this is followed by an exposition of Cohen's experiments on allotropic tin, a short and masterly exposition of the metallurgy of iron, and the relations between α and β ferrite, pearlite, cementite, and carbon.

In considering the bearing of physical chemistry on physiology, the measurement of osmotic pressure by *tradiscantia discolor,* and by blood-corpuscles, and the curious experiments on the human eye by Dr. Massart are discussed, as well as Loeb's discovery of the *rôle* of osmotic pressure in fertilisation. The influence of enzymes as accelerators or retarders of chemical action, and their effect in promoting synthesis as well as decomposition are particularly alluded to.

The last chapters, dealing with geological phenomena, are suggestive; the type chosen is the very complicated relationships between the Stassfurt salts, in which no fewer than twenty-six components are present. A graphic representation of the conditions under which these salts are capable of existence is annexed.

Prof. van 't Hoff possesses in an almost unique degree the power of simple exposition and suggestiveness. On reading this book one is tempted to exclaim, "Why was all this not thought of ages ago?" But the fact is, all great discoveries can be simply stated, but it usually needs a great discoverer who can add to his discoveries simple methods of exposition. The magic consists in clearness of thought, and this is admirably illustrated in this interesting book.

W. R.

SCHOOL MATHEMATICS.

A School Geometry. Parts i.–v. By H. S. Hall, M.A., and F. H. Stevens, M.A. Pp. xii+340+ix. (London: Macmillan and Co., Ltd., 1903.) Price 4*s.* 6*d.*

Exercises in Theoretical and Practical Geometry. By R. B. Morgan. Pp. 96. (London: Blackie and Son, Ltd., 1903.) Price 1*s.*

Graphs: or the Graphical Representation of Algebraic Functions. By C. H. French, M.A., and G. Osborn, M.A. Pp. vii+64. (London: W. B. Clive.) Price 6*d.*

PART V. of the new geometry by Messrs. Hall and Stevens has been recently issued, and the whole work, so far as it is completed, is now conveniently published in one volume. The final part, dealing with solid geometry, is in preparation, and will be awaited with interest in many quarters.

The authors follow the reform movement cautiously, on strictly orthodox lines, and adhere closely to the recommendations of the Mathematical Association and to the new Cambridge syllabus. The advantages of the newer methods of teaching geometry are very manifest in this excellently written text-book. A great change has been effected in the country in a comparatively short time, but the subject is not yet sufficiently emancipated from the older influences. The field of elementary geometry is at present only partially covered. We are strongly of opinion that examiners, teachers and writers should take a more comprehensive view of the scope of the subject. The scheme still generally followed in schools deals only with the shapes and sizes of figures, and takes no account of their relative positions. That is, attention is confined to scalar properties, and a vital portion of this essentially vector subject is ignored. It seems to us that boys at school should receive some account of the geometry of space, that is, they should be introduced to the conception and domain of vectors. This domain is far reaching and of supreme importance, and in subsequent study is seldom fully comprehended because, in the supposed interests of logic, persons responsible for the teaching of geometry have neglected a part of their duties and have failed to treat the subject in a thorough manner. The foundation of a knowledge of vectors should be laid in the geometry and drawing classes, where it can be done appropriately and effectively, and able writers like the present authors could exert much influence for good by introducing the subject in their deservedly popular text-books.

Mr. R. B. Morgan's book consists of a collection of more than six hundred exercises in geometry, together with a few specimens of recent examination papers, the purpose of which seems to be to illustrate the course of geometry as outlined in the new Cambridge schedules. No answers are given to the examples, or hints for solution or explanations of any kind, and the book is only adapted for use in conjunction with an ordinary text-book. In the latter sufficient examples are usually provided, and generally of a superior merit to those under review, so that the sphere of usefulness of Mr. Morgan's book seems likely to be very restricted.

The text-book by Messrs. French and Osborn is one of the University Tutorial Series. It is a supplement to the "New Matriculation Algebra" of the series, and is intended primarily for students preparing for the London matriculation examination. The subject is introduced by some typical examples of statistical graphs, in which special attention is paid to the choice of scales and the kind of information to be obtained from graphs. The authors then at once proceed to the development of the properties of algebraical functions by means of graphs, the examples being confined mainly to equations of the first, second and third degrees. The problems dealt with relate to maxima and minima values, the solution of equations, limiting values and asymptotes, symmetrical properties, and the determination of algebraical curves to pass through two, three, or four points.

It will thus be seen that trigonometrical, exponential and logarithmic functions are outside the scope of the work, as are also considerations relating to slope, rate of increase, and the calculus. But the ground that is mapped out by the authors is well covered, and the book will be found very useful to the class of students for whom it is intended.

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